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Technical Report **R-022** DEVELOPMENT OF 21-FT WIDE END-TO-END CONNECTED NL PONTOON CAUSEWAY

U. S. NAVAL CIVIL ENGINEERING LABORATORY

Port Hueneme, California

AD 205595

DEVELOPMENT OF 21-FT WIDE END-TO-END CONNECTED NL PONTOON CAUSEWAY

NY 120 004-2.03
Final Report

Type C

20 March 1959

by

R. C. Towne

U. S. NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California

FOREWORD

Military operations during amphibious landings have shown the need for developing a means of unloading materiel from ship to shore. One concept is the side lapped Navy Lighter pontoon causeway; however, some operations, such as unloading of equipment in areas of extreme tidal ranges, have indicated a need for causeway improvements. In 1949 the Bureau of Yards and Docks initiated a contract with Anderson-Nichols Company, Boston, Massachusetts, to provide a method to join causeway sections end to end. An evaluation of this method led the Laboratory into the development of the equipment described in the body of this report. The equipment developed by the Laboratory has undergone engineering tests and the Chief of Naval Operations has initiated in-service evaluation by the Operating Forces. The report describes the development phase, initial in-service evaluation and includes results of a landing exercise conducted with the causeway near Camp Pendleton, California, in September 1958.

SUMMARY

OBJECT OF PROJECT

The objective is to provide suitable prefabricated structures for facilitating the movement of vehicles over unstable terrain and the ship to shore unloading of heavy equipment over all types of sea bottoms and extreme tidal ranges.

OBJECT OF SUBPROJECT

The purpose of this subproject is to develop a 21-ft (feet) wide, end-to-end connected, NL pontoon causeway capable of operation in 4-ft to 6-ft surf and able to act both as a floating roadway and a roadway which can rest on tidal mud flats and support the passage of vehicles.

OBJECT OF REPORT

This final report describes the development and in-service evaluation of a 21-ft wide, end-to-end connected, NL pontoon causeway.

RESULTS

The subject causeway successfully completed the engineering tests made at the Laboratory and to date has performed satisfactorily with minor exceptions during the in-service evaluation being conducted by PHIBCB One; however, observations of initial in-service tests have indicated considerable difficulty in securing LST's to the end of the causeway.

ABSTRACT

The Bureau of Yards and Docks directed the Laboratory to develop a 21-ft wide end-to-end connected NL pontoon causeway suitable for unloading materiel at landing areas subject to extreme tidal ranges.

The Laboratory developed a 3 x 15 NL pontoon causeway with a "hinge" type end connection, which can operate in 4-ft to 6-ft waves, be moored in a 40 mile per hour wind, withstand a 3-knot current parallel to beach, and is suitable for operation in areas of extreme tidal ranges. Sixty ton tanks can be moved over the causeway without difficulty; vehicle speeds of 15 mph can be attained in moderate surf.

It was concluded that the subject causeway will meet the criteria formulated by Budocks and, in addition, can be left moored on the beach in 8-ft to 12-ft surf conditions. The present marriage system for joining the causeway to an LST is unsatisfactory in surf conditions over 2 ft in height.

It is recommended that the 3 x 15, end-to-end connected NL pontoon causeway be subjected to an in-service evaluation. A study to provide an improved system for marrying the causeway to the LST is also recommended.

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INTRODUCTION

The Bureau of Yards and Docks for some time has had the requirement for an improved causeway for supporting combat vehicular traffic from ship to shore. In 1949, Contract NOy-19307, issued by BuDocks, initiated several investigations to provide this improved or new equipment. Criteria for causeways for amphibious operations (Appendix A) were formulated by BuDocks[1] based upon operational requirements. In addition, one requirement was for an end connection which could be attached to the present T7A pontoons with a minimum of modification to the pontoon. Also, joining of the causeway sections was to be completed by hand or with warping tug equipment. This report describes the preliminary investigation and details the developmental phase conducted at NCEL and in-service evaluation made by the Operating Forces to date.

The final report on U. S. Naval Contract NOy-19307, April, 1950, proposed a method of joining 2 x 30 causeway sections end to end. The Laboratory began fabricating this connection in 1950. Results of the test[2] on this "side chain connection" indicated that the 175-ft length of the 2 x 30 causeway caused large stresses to be imposed at the end points and consequently tended to break any type of connector mounted at these end points. The "side chain connection" was also very flexible, making it difficult to maneuver the causeway to the beach (Figure 1).

Subsequent model studies were made in a wave tank at the Laboratory to determine the length of causeway section which would most closely follow the expected wave patterns. It was found for almost all wave conditions, a causeway section length of 80 ft to 100 ft was suitable. The straight length side of an LST is approximately 180 ft; therefore, a 3 x 15 causeway section, approximately 89-ft long was selected as providing the optimum causeway length for a given number of LST's. One LST can carry four sections with the necessary end connections installed. BuDocks subsequently directed[1] the Laboratory to develop a 21-ft wide end connected causeway.

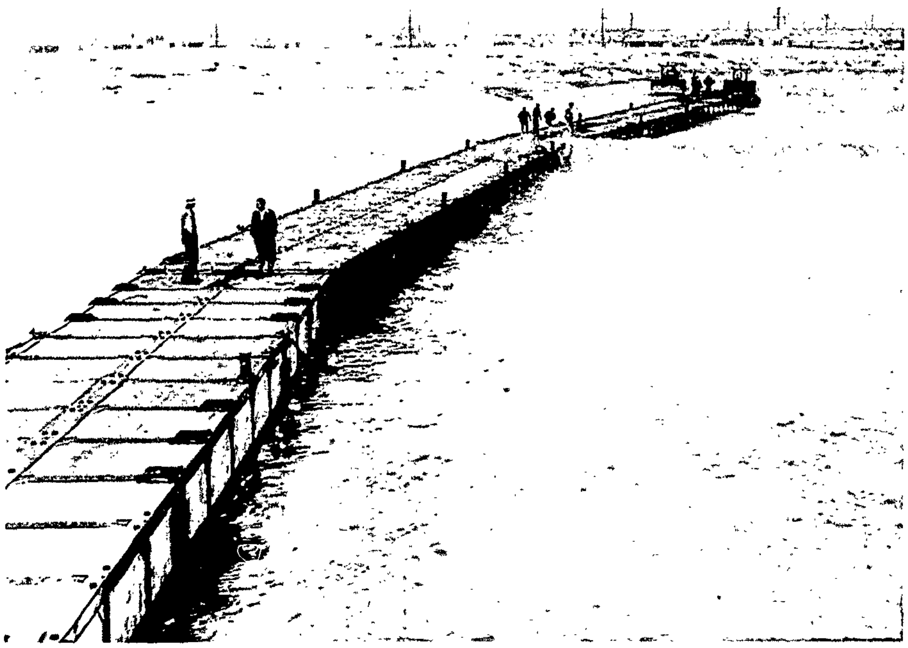


Figure 1. 2 x 30 pontoon causeway joined end to end by "side chain connection". Note bow in causeway due to flexibility in connection.

DEVELOPMENT

A "hinge" type connector was designed and tested at the Laboratory (Figure 2). One portion of the connection was made from a 6-in. diameter reinforced pipe section and the other part was made from a half section of 8-in. diameter pipe. These two parts of the connection resist the vertical shear, torsion and compression forces in the joint and 1-1/2 in. diameter bridge strand wire ropes formed the tension members to hold the sections together.

Based on the results of tests[3] made on this connection, the "hinge" portions were strengthened and a "link and pad eye" tension member was substituted for the wire rope tension member (Appendix B).

The "link and pad eye" was simpler to fabricate than the wire rope members and presented no storage or handling problems (Figures 3 and 4). This connection was tested[4] at the Laboratory and subsequently the connections and causeway sections were transferred to Amphibious Construction Battalion One, Coronado, California, for additional evaluation.

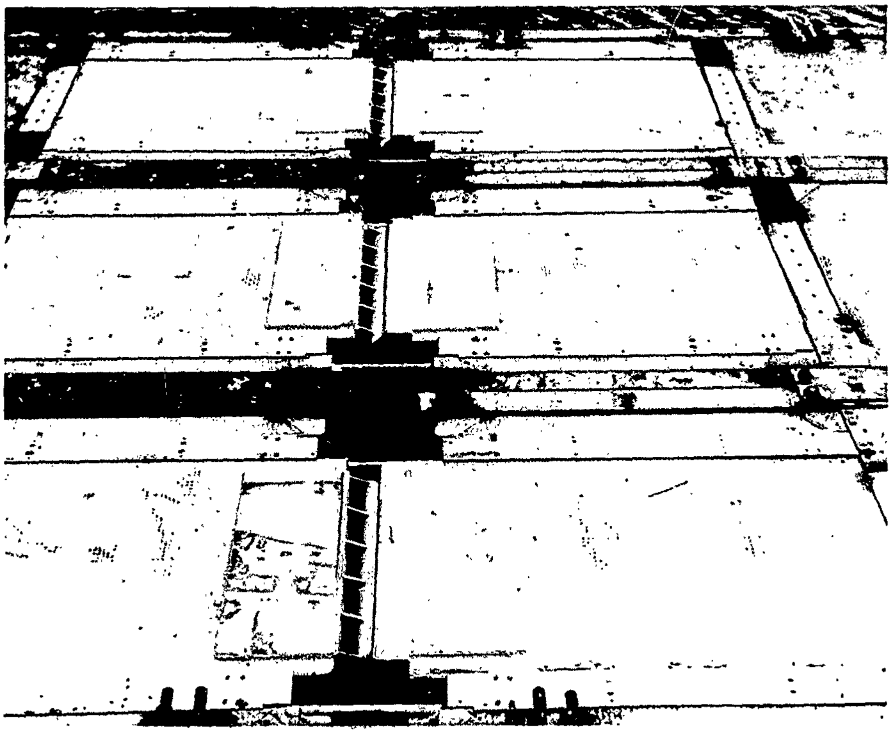


Figure 2. Two 3 x 15 sections joined with six 1-1/2 in. diameter wire rope connectors.

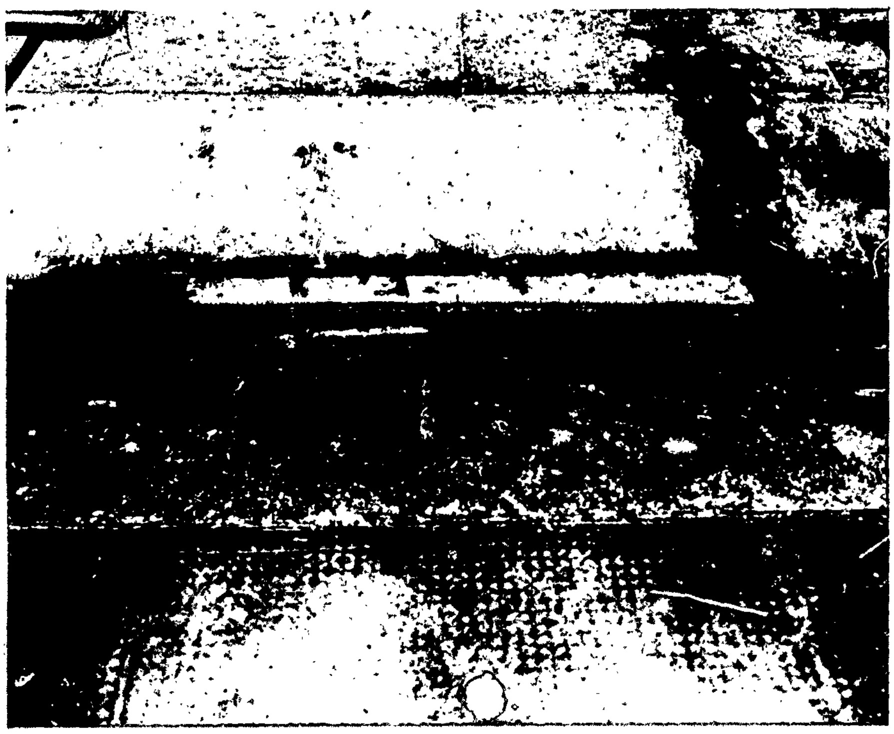


Figure 3. CEC-2A connection joining one string of a 3 x 15 section.

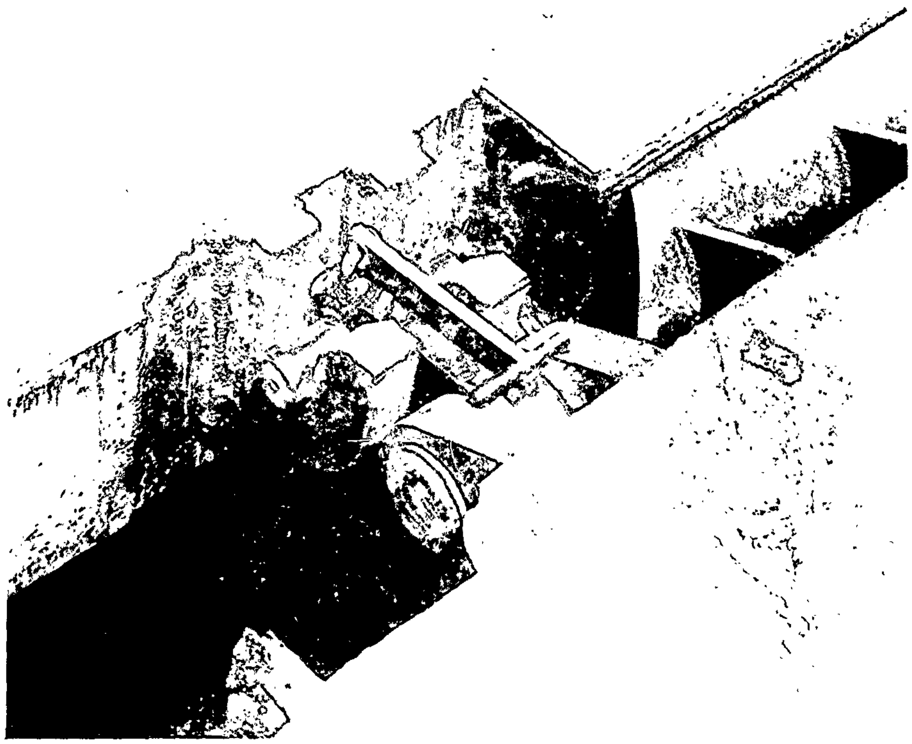


Figure 4. Link and pad eye connector in closed or connected position.

IN-SERVICE EVALUATION

PHIBCB One conducted tests during 1957 using sections joined with wire rope tension members, and reported satisfactory operation (Figure 5).

In December 1957, the Chief of Naval Operations directed[5] that an in-service evaluation of the 21-ft wide end-to-end connected causeway be made.

By February 1958, PHIBCB One prepared 10 causeway sections for in-service evaluation. Five sections were equipped with wire rope tension members and five sections with the link and pad eye tension members. This provided a comparative test of the two types of tension members. Tests[6] were conducted during the weeks of 3 March and 17 March 1958 (Figures 6 through 9).

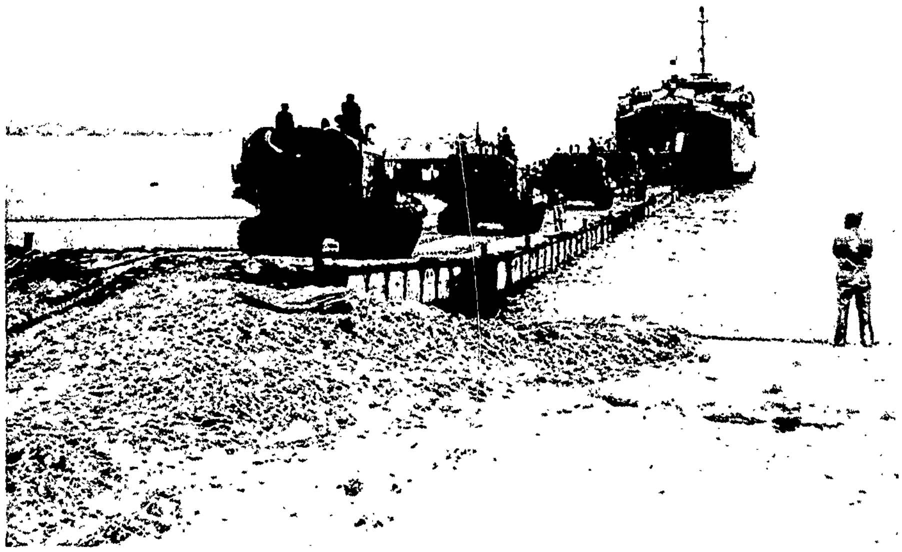


Figure 5. Loading 50 ton tanks across 21-ft wide end-to-end connected causeway.

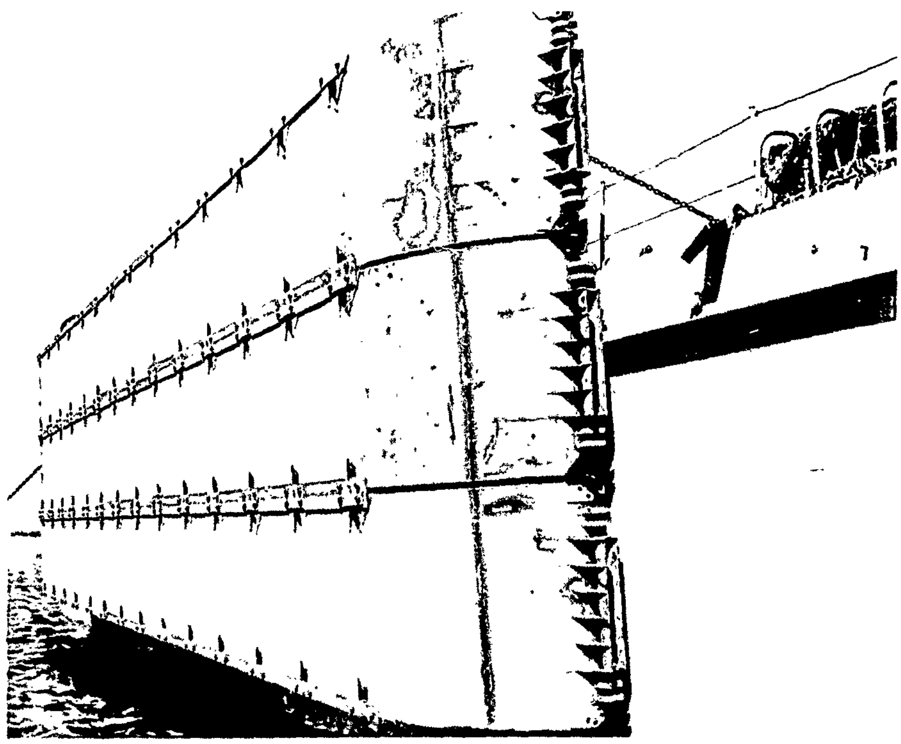


Figure 6. 3 x 15 section side loaded on LST.

Figure 7. 3 x 15 causeway approaching beach.

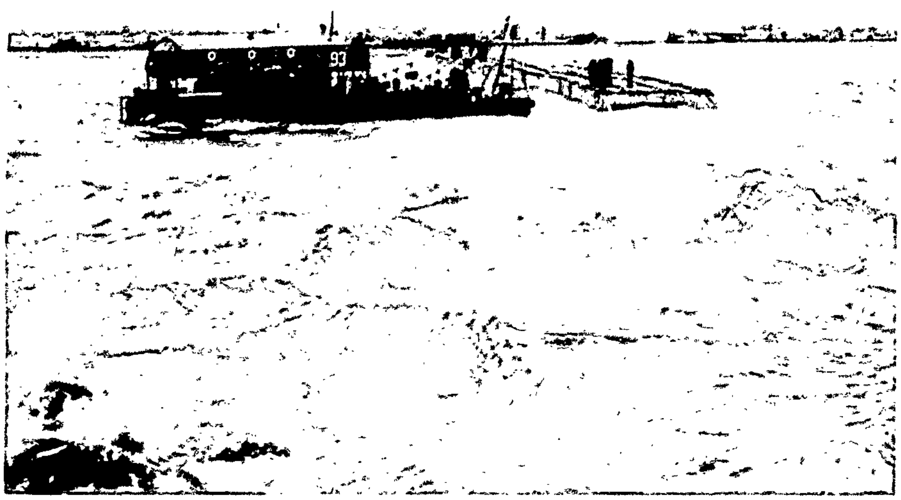


Figure 8. Ten section causeway on beach during tests conducted during week of 3 March 1958.

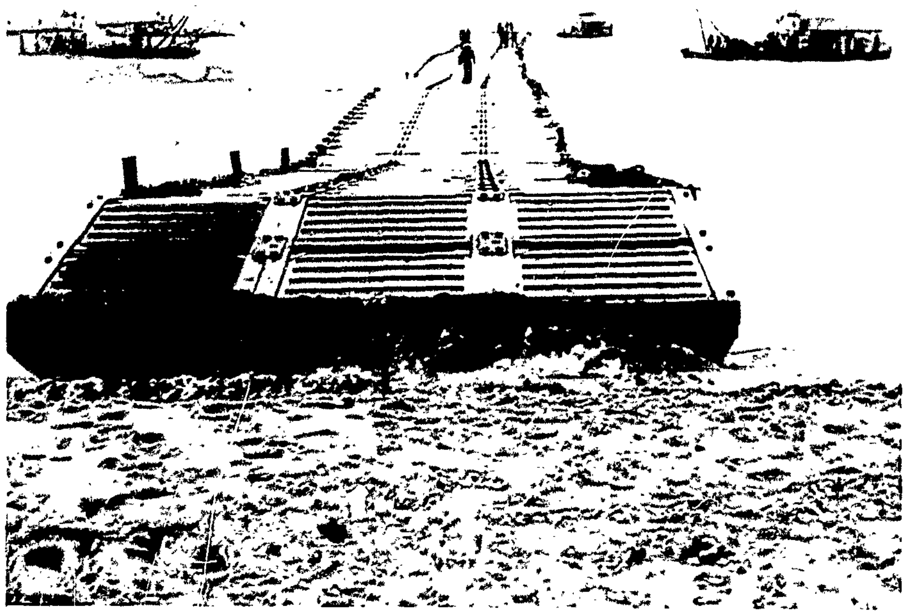


Figure 9. Causeway beached in 4 ft to 6 ft surf.

During the week of 3 March 1958 four 3 x 15 sections were loaded on an LST, Class 1156. Two sections were self side loaded using the ship winch and two sections were loaded using the 100-ton capacity AB floating crane. Horizontal and vertical turnbuckles were used to secure the sections to the LST (Figure 10). Chains were also used to lash causeway to LST deck to prevent shifting of the causeway while underway. The remaining six sections were towed to sea by warping tug to rendezvous with the LST. The weather was rainy with 3-ft to 4-ft swells and white caps on the water. The four sections were side launched from the LST and joined to the other six sections by warping tug. The ten section causeway, approximately 890-ft long, was beached in line with range markers in 4-ft to 6-ft breakers. No difficulties were encountered. The surf became too rough for the LST to marry to the causeway so the ten sections were left installed over night. Breaker height increased to 10 ft and 12 ft during the night and next day, but the causeway was still operable after this period.

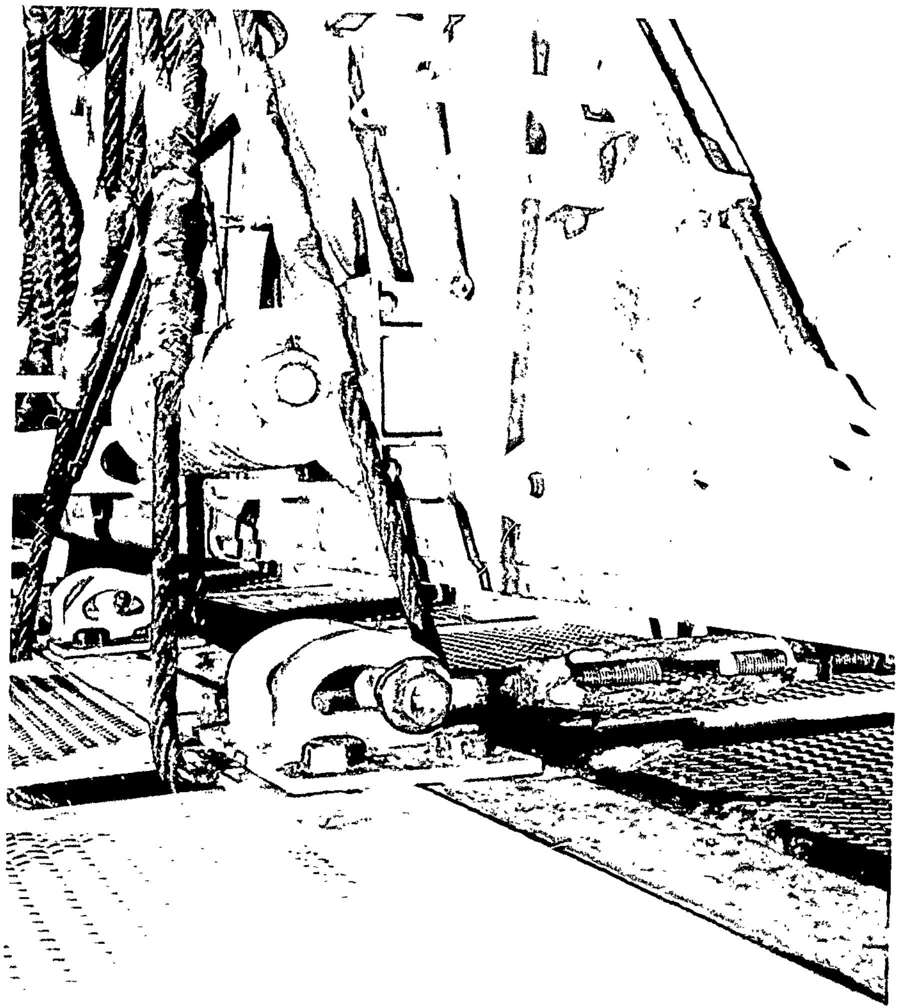


Figure 10. Turnbuckles used to secure 3 x 15 section to LST.

During the second week, 17 March, 4 sections were loaded on an LST Class 542. Again, no major difficulties were encountered. The remaining six sections met the LST at sea; and, after side launching, the sections were joined end to end. Average time to join one section was 5 minutes. The causeway was beached and the equipment on the LST was unloaded. No difficulty was encountered in handling trucks, ducks, tractors, tanks, and gun trailers over the causeway. As a result of these tests, PHIBCB One recommended[6] that the 3 x 15 end-to-end connected causeway, using link and pad eye connections, be adopted for in-service use.

In September 1958, PHIBCB One installed an 8 section causeway with link and pad eye connectors near Camp Pendleton, California, during a landing exercise. Some difficulty was encountered in securing the LST to the causeway; however, once the connection was made, the equipment and personnel had no difficulty in unloading over the causeway. A movie[7] was taken by the Laboratory showing the early development stages of the end-to-end connections and the operational and in-service evaluation conducted by PHIBCB One.

OBSERVATIONS

Laboratory observers were present during operational and in-service tests conducted by PHIBCB One. Several items were noted which appeared to warrant improvement or investigation. A 3 x 15 section weighs less (approximately 70 tons) than a 2 x 30 section (approximately 90 tons) and, therefore, presents no particular problem in the side loading on an LST using the ship winch. Some rearrangement of the lifting rollers on the LST deck appears necessary and a new hold down clamp is required. The present hold down clamp is designed to fit on a single pontoon angle of a 2 x 30 causeway. The 3 x 15 causeway has a double pontoon angle where the hold down clamp is to be positioned. The total weight on the LST hinge rail of two 3 x 15 sections is greater than the one 2 x 30 section; therefore, the structural adequacy of this hinge rail should be investigated.

Considerable difficulty was observed in securing LST's to the end of the causeway. The present marriage system is unsatisfactory in surf conditions over 2 ft in height. An improved system is definitely required. One suggestion, now being investigated by PHIBCB One,

is the utilization of three point mooring system. This mooring system would be used by the LST to align with the causeway end, pull itself to the section, and then assist in holding its position. This method may facilitate the LST marriage, but the necessity for further improvement is indicated.

Track vehicles caused damage to the hinge cover plates which cover the openings between the end connections. A better method of covering these openings is being investigated.

Momentum beaching tests[8] were conducted by PHIBCB One (Figure 11); however, no adjustable causeway section has been designed which will allow the causeway length to be varied between a grounded LST and the beach. Further study into this problem is required.

Figure 11. LST momentum beaching 3 x 15 causeway.

CONCLUSIONS

The 3 x 15 causeway with end connectors, CEC-2A, meets Budocks criteria. The equipment can be moored in 8-ft to 12-ft surf conditions.

The present method of securing the LST to the causeway needs improvement. The use of a three-point mooring system facilitates the marriage of the ship to the end section.

The 3 x 15 end connected causeway provides a wider roadway than the present 2 x 30 causeway which enables the 3 x 15 causeway to handle any equipment that can be carried on an LST.

The 3 x 15 end connected causeway is more maneuverable than the side lapped 2 x 30 causeway. In addition, this causeway can withstand surf action better than the 2 x 30 causeway due to the shorter length of section and flexibility of the joints.

RECOMMENDATIONS

It is recommended that:

1. The 3 x 15 NL pontoon causeway with end connector, CEC-2A, link and pad eye, be subjected to an in-service evaluation.

2. Necessary modifications of the causeway system as disclosed during in-service evaluation be reported for inclusion into the drawings.

3. Further study be made of the adjustable causeway section for use with a grounded LST.

4. Efforts be continued to develop improved marriage gear, hold down clamps and connection cover plates.

REFERENCES

1. BuDocks Directive ltr D-410D/SG, dtd 6 Dec 1954 to NCEL.

2. NCEL Technical Note N-026, "Anderson-Nichols End-to-End Connection for Pontoon Causeways," dated 8 May 1951 by R. C. Towne.

3. NCEL Interim Memorandum Report E-LR-38, "Development and Test of 21-ft Wide NL Pontoon Causeway," dated 7 January 1957 by R. C. Towne.

4. NCEL Memorandum Report E-LR-57, "Development and Test of 21-ft Wide NL Pontoon Causeway," dated 24 August 1957 by R. C. Towne.

5. Chief of Naval Operations ltr Ser: 273 PO3C of 19 December 1957.

6. "Evaluate for Service Use the 21-ft Wide End-to-End Connected Pontoon Causeway," by PHIBCB One, 1958.

7. NCEL color movie, "Development of the 21-ft Wide End-to-End Connected NL Pontoon Causeway," 16 mm with magnetic sound, 23 minutes.

8. PHIBCB One ltr Ser: 438 to Naval Beach Group One of 16 July 1958.

APPENDIX A. Criteria Governing Design of Floating Causeways for Amphibious Operations.

Type - The causeway shall be designed as both a floating roadway and a roadway which can rest on tidal mud flats or sea bottoms.

Sea Bottom Characteristics - The causeway shall be designed, aside from flotation, primarily so that it can rest on extensive tidal mud flats and support the passage of vehicles in an amphibious operation. If the designed causeway will also traverse other types of sea bottoms such as sand, coral, rock or other irregular surfaces without sacrificing the ability to traverse mud flats, its value would be even greater.

Load - The maximum load will be a 60-ton moving vehicle (track type). This load may be assumed as a tank, with dimensions of 148" overall width, 275" overall length, and 58" overall height. The minimum roadway spacing between vehicles for this load will be assumed as 240'. The maximum operating speed will be 15 mph.

Length - The length of the causeway will be a maximum of one mile. This is based on an assumed beach slope of 1 to 100, a 30' tide range, and a maximum LST draft of 17'. However, it is expected that beaches with slopes steeper than 1 in 100 will be more often encountered.

Width - A minimum roadway width of 18' - 6" will be required to provide for 2 way truck traffic. The maximum width is 21' - 0" based on the allowable width that can be side carried on an LST.

Element Length - The causeway is assumed to be a structure composed of basic elements connected in tanden by either rigid or flexible end-to-end connections. The minimum length of such an element shall be 60'. The maximum length of an element shall be such that the weight is not excessive for normal handling facilities and shall not exceed the straight length side of an LST (approximately 180'). Each basic element should be the same to allow for interchangeability.

There are two basic conditions which govern element length:

a. In the condition afloat, design must consider a wave height of 4' and wave length of 80'. End-to-end conditions, whether flexible or rigid, must be so designed that they will support all imposed loads, no matter where the position of the connection in relation to the span.

b. In the condition of resting on sea bottom, the elements may be either flexibly or rigidly connected, but the causeway must support the imposed loads, regardless of the position of the connection in relation to the span.

There may be localities where sea bottom profiles show span distances (from one high point to an adjacent high point) greater than 60' or the designed element length. These span distances are not determinable. It is assumed that a rigidly connected structure will not be designed to support a 60-ton load over a span-length which is greater than the causeway element length. Consequently, provisions should be made in the design to allow a rigidly connected causeway to conform to the profile of the sea bottom when span lengths are encountered which exceed the causeway element length.

Installation - In the mile-long causeway, the first 3000' of structure extending from the shore should be installed within two hours from the time the first causeway unit is beached.

Causeway elements may be assembled into 500' length units in an assembly area and towed to the assault zone. Such 500' units must be fitted for tows up to ten miles in distance.

The balance of 2280' of causeway should be installed in another four hours.

Any design which will permit more rapid assembly and installation would be even more acceptable.

Anchorage - Adequate anchorages shall be provided for lateral stability (both flotation stability and side movement) against a 40 mph wind, 4' waves, and a 3 knot tidal current (parallel to shoreline.)

Off-shore End - The off-shore end of the causeway must be designed so that it can be married to an LST or can be attached to a floating wharf.

Launching - Elements of a causeway are presumed to be side-carried and launched by LST's (see notes on Width). Consideration may be given to a causeway and carrying design which would permit the entire mile of causeway to be carried in one LST equipped with handling facilities, but in any case, the causeway elements must be designed for side-carry.

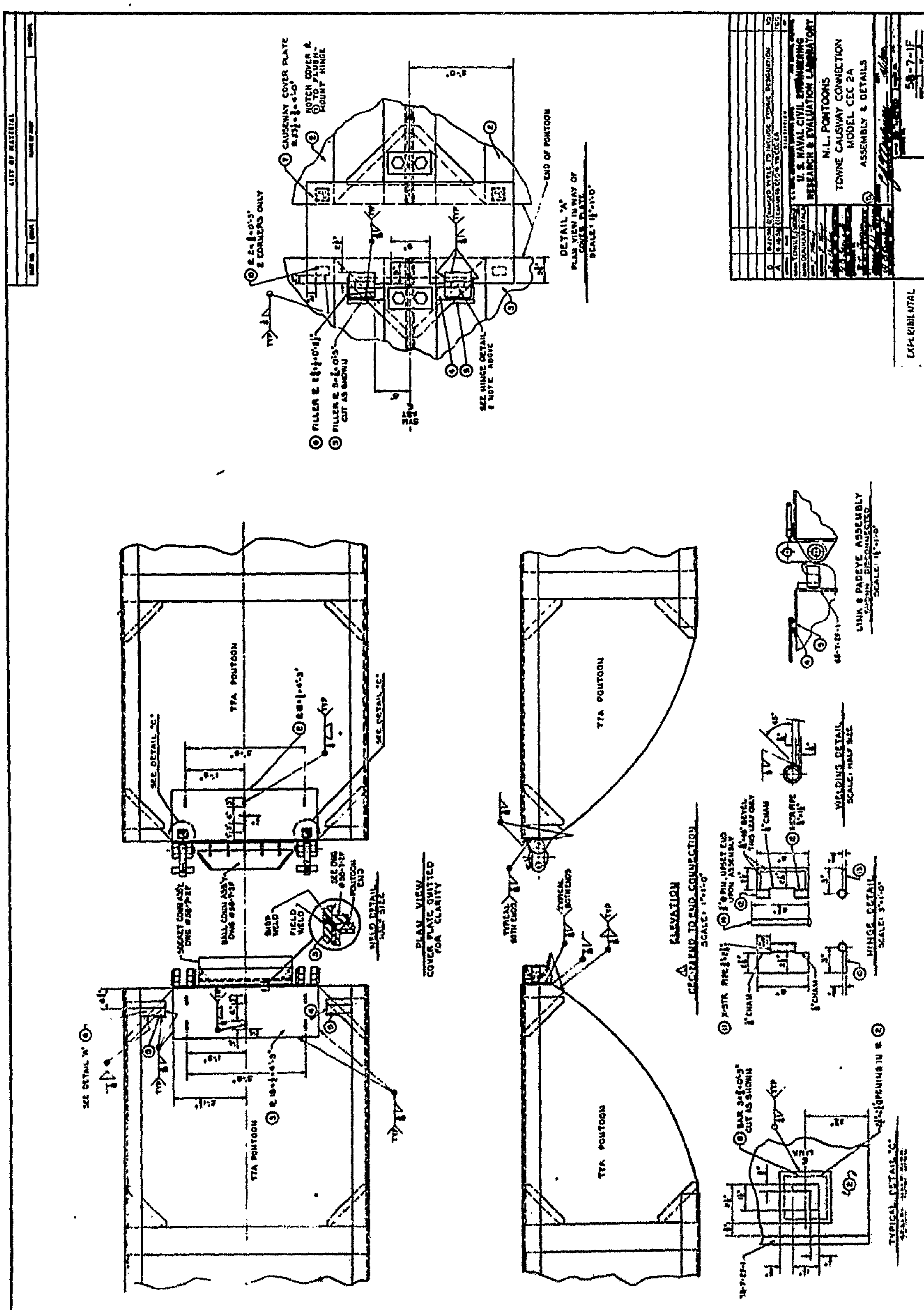
Utility - The causeway will be primarily designed for crossing mud flats and its longevity and durability for this purpose are paramount requirements. If the causeway elements can be easily disassembled and used for other purposes without jeopardizing their future use as causeway elements, then they may be so designed.

Repairability - The causeway elements and connections should be so designed that they can be easily and readily repaired or replaced.

Vulnerability - The causeway should be so designed that its vulnerability to enemy action (mines, underwater obstacies, artillery, aircraft) would be reduced to a minimum.

Portability - The size and weight of the causeway elements should be such that they require a minimum space in transportation.

Field Assembly - For transportation from the zone of interior to an advanced base the causeway may be broken down into parts for better stowage. However, the design should be such that assembly at the advanced base can be made with a minimum of welding and without excessive requirements of men, equipment or time.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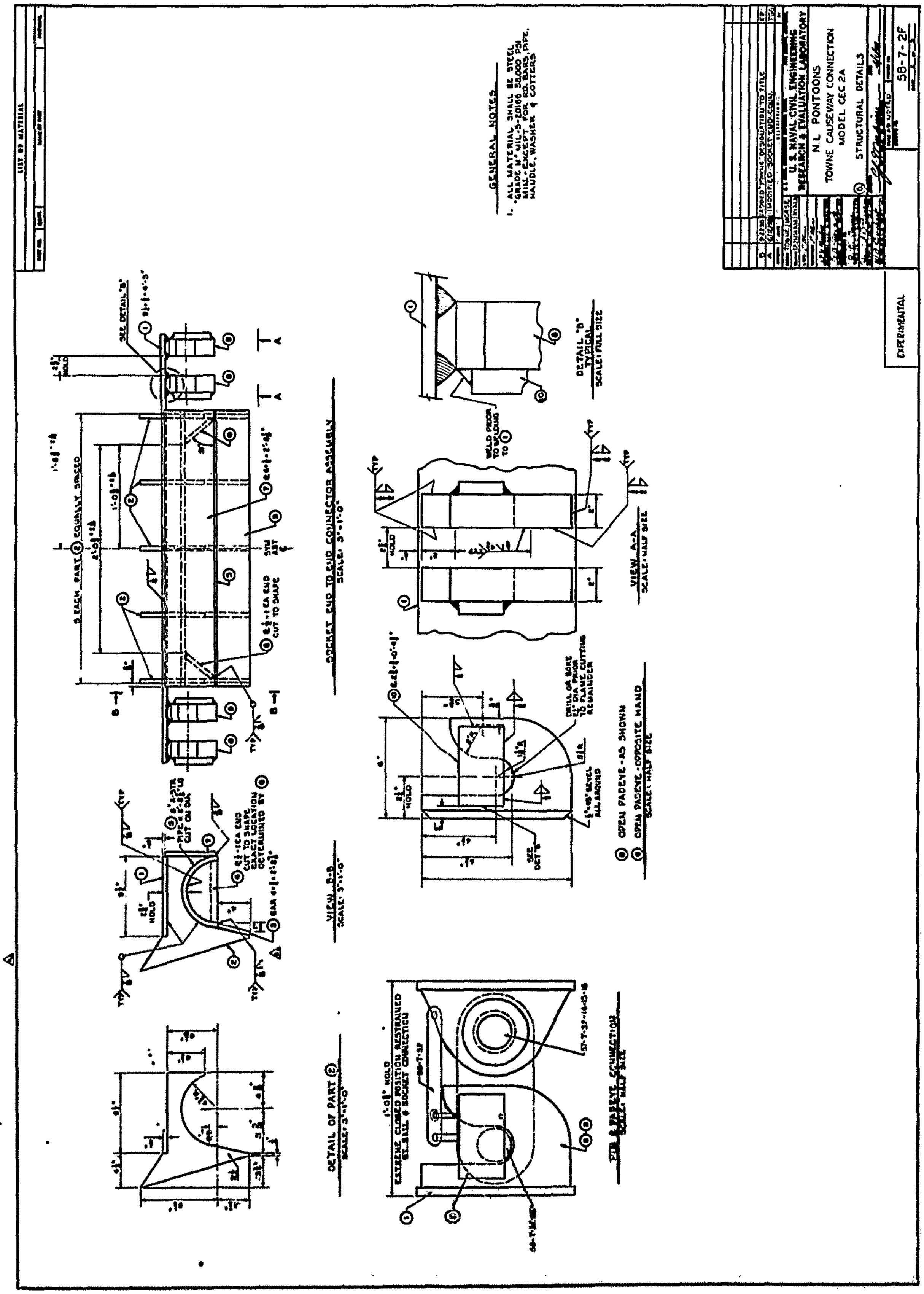
RESEARCH & EVALUATION LABORATORY
N.L. PONTOONS
TOWNE CAUSEWAY CONNECTION
MODEL CEC 2A
ASSEMBLY & DETAILS
58-7-1F
LIST OF MATERIAL
DETAIL "A"
END OF PONTOON
TFA PONTOON
PLAN VIEW
COVER PLATE OMITTED FOR CLARITY
ELEVATION
END TO END CONNECTION
WELD DETAIL
HINGE DETAIL
WELDING DETAIL
LINK & PADEYE ASSEMBLY
TYPICAL DETAIL "C"
SEE DETAIL "C"


GENERAL NOTES
1. ALL MATERIAL SHALL BE STEEL "GRADE N" MIL-S-20166 30,000 PSI MIN.-EXCEPT FOR RD. BARS, PIPE, HANDLE, WASHER & COTTERS
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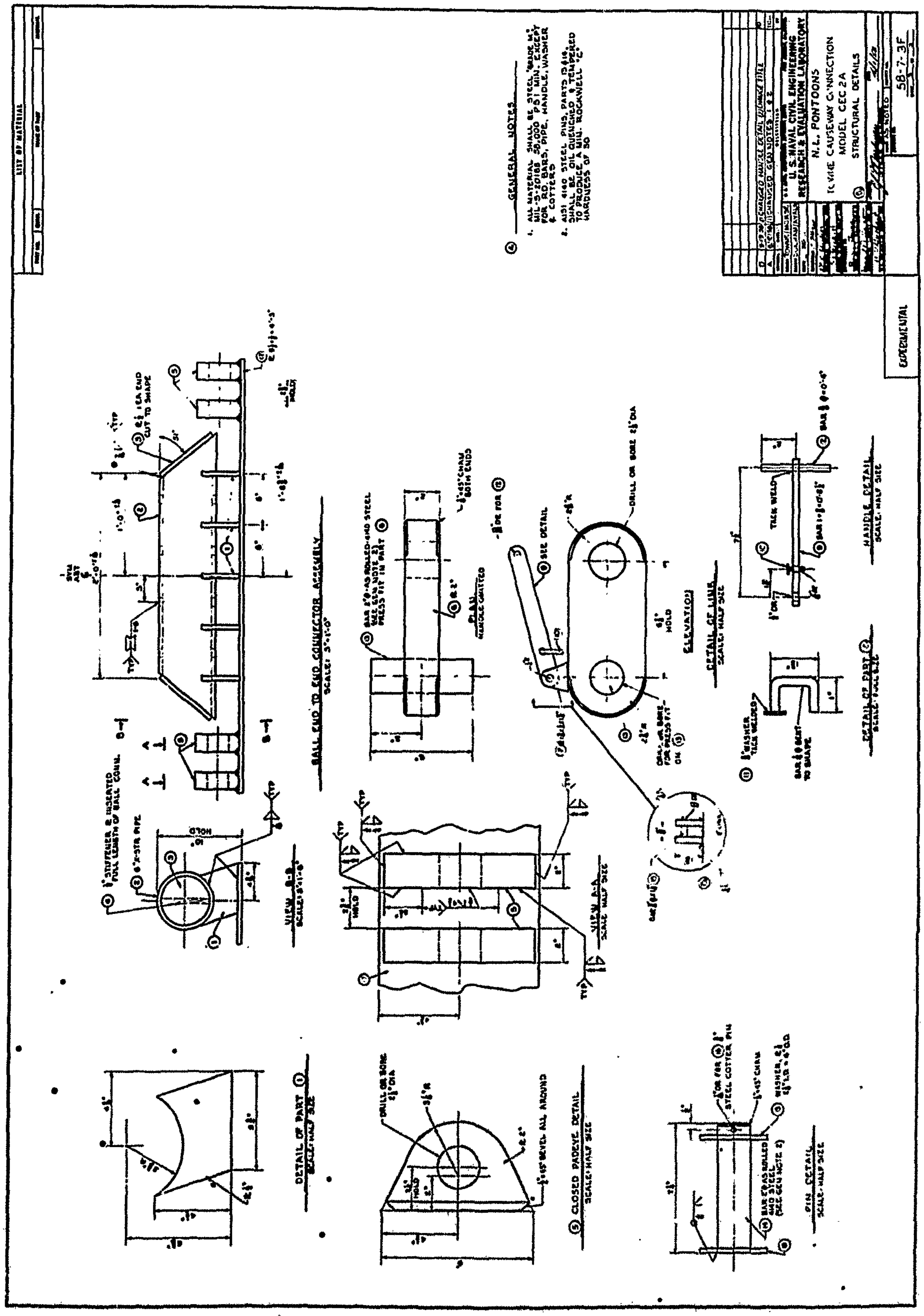
N.L PONTOONS
TOWNE CAUSEWAY CONNECTION
MODEL CEC 2A
STRUCTURAL DETAILS
58-7-2F
EXPERIMENTAL
SOCKET END TO END CONNECTOR ASSEMBLY
VIEW B-B
DETAIL OF PART
VIEW A-A
DETAIL "B" TYPICAL
OPEN PADEYE - AS SHOWN
OPEN PADEYE - OPPOSITE HAND
LIST OF MATERIAL


GENERAL NOTES
BALL END TO END CONNECTOR ASSEMBLY
DETAIL OF LINK
HANDLE DETAIL
CLOSED PADEYE DETAIL
PIN DETAIL
DETAIL OF PART
EXPERIMENTAL
U.S. NAVAL CIVIL ENGINEERING RESEARCH & EVALUATION LABORATORY
N.L. PONTOONS
MODEL CEC 2A
STRUCTURAL DETAILS

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